The Science of

# Animal Locomotion

(Zoopraxography)

An Electro-Photographic Investigation of

## Consecutive Phases of Animal Movements

By

Eadweard Muybridge

Executed and Published under the Auspices of the

University of Pennsylvania

Description of the Apparatus
Results of the Investigation
Diagrams
Prospectus
List of Subscribers

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THE SCIENCE OF

# ANIMAL LOCOMOTION

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AN ELECTRO-PHOTOGRAPHIC INVESTIGATION OF

## CONSECUTIVE PHASES OF ANIMAL MOVEMENTS

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UNIVERSITY OF PENNSYLVANIA



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# ANIMAL LOCOMOTION.

## (ZOOPRAXOGRAPHY.)

### INTRODUCTORY.

In 1872, the author of the present work in Sacramento, California, commenced an investigation with the object of illustrating by photography some phases of animal movements. In that year his experiments were made with a famous horse—Occident, owned by Senator Stanford—and photographs were made, which illustrated several phases of action while the horse was trotting at full speed, laterally, in front of the camera.

The experiments were desultorily continued; but it was not until 1877 that the results of any of them were published.

In the meanwhile he devised an automatic electro-photographic apparatus, for the purpose of making consecutive photographic exposures at *regulated* intervals of time or of distance. Some of the results of his experiments with this apparatus, which illustrated successive phases of the action of horses while walking, trotting, galloping, &c., were published in 1878, with the title of "The Horse in Motion." Copies of these photographs were deposited the same year in the Library of Congress at Washington, and some of them found their way to Berlin, London, Paris, Vienna, &c., where they were commented upon by the journals of the day.

In 1882, during a lecture on "The Science of Animal Locomotion in its relation to Design in Art," given at the Royal Institution (see *Proceedings* of the Royal Institution of Great Britain, March 13, 1882), he exhibited the results of some of his experiments made during a few antecedent years at Palo Alto, California; when he, with the zoopraxiscope and an oxy-hydrogen lantern, projected on the wall a synthesis of many of the actions he had analysed.

It may not be considered irrelevant if he repeats what he on that occasion said in his analysis of the quadrupedal walk:—

"So far as the camera has revealed, these successive foot fallings are invariable, and are probably common to all quadrupeds. . . . .

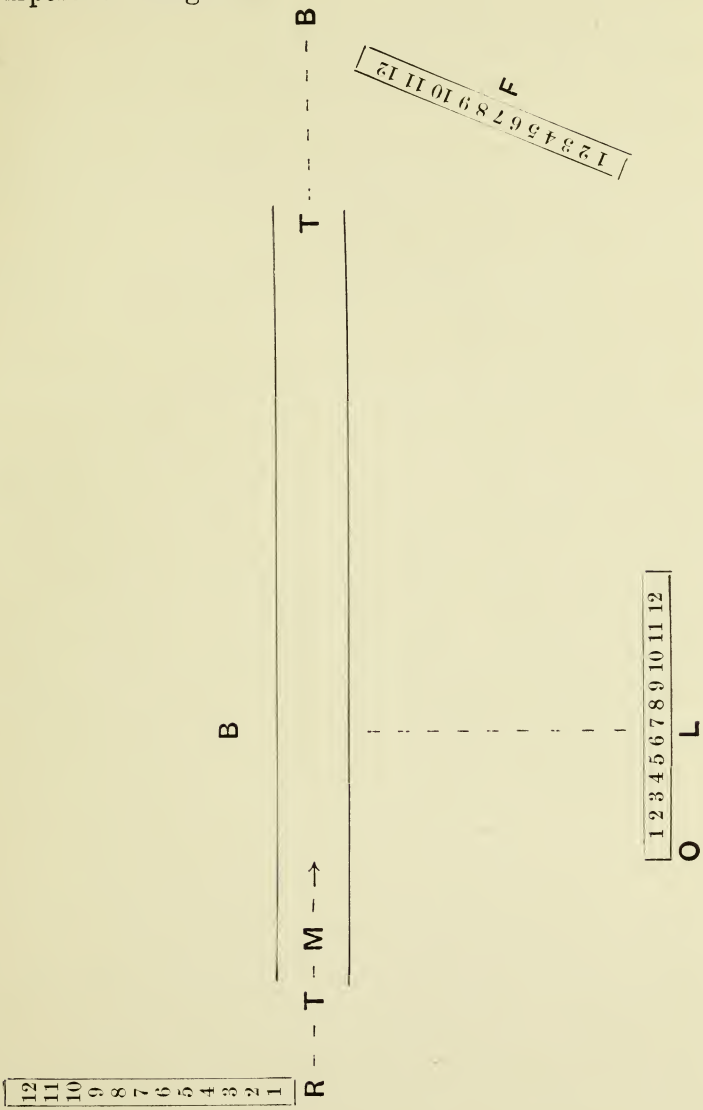
"It is also highly probable that these photographic investigations—which were executed with wet collodion plates, with exposures not exceeding in some instances the one five-thousandth part of a second—will dispel many popular illusions as to the gait of a horse, and that future and more exhaustive experiments, with the advantages of recent chemical discoveries, will completely unveil to the artist all the visible muscular action of men and animals during their most rapid movements. . . . .

"The employment of automatic apparatus for the purpose of obtaining a regulated succession of photographic exposures is too recent for its value to be properly understood, or to be generally used for scientific experiment. At some future time the explorer for hidden truths will find it indispensable for his investigations."

In 1883, the University of Pennsylvania, with an enlightened exercise of its functions as a contributor to human knowledge, instructed the author to make, under its auspices, a comprehensive investigation of "Animal Locomotion" in the broadest significance of the words.

A Diagram of the Studio

and the arrangement of the apparatus used for this purpose is here given.



T T represents the track along which the model M was caused to move. B B are backgrounds, divided into spaces of 5 centimetres square for the measurement of trajectories and synchronal oscillations.

L, a horizontal battery of electro-photographic cameras, parallel to the line of motion (at a distance of 15 metres or about 48 feet therefrom), for a series of 12 lateral exposures.

R, a vertical battery of electro-photographic cameras, at right angles to the lateral battery, for a series of 12 *rear* foreshortenings.

F, a horizontal battery of electro-photographic cameras, at any suitable angle to the lateral battery for a series of *front* foreshortenings.

O, the position of the electric batteries, a chronograph and other apparatus used in the investigation.

A clock-work apparatus, set in motion at the will of the operator, distributed a series of electric currents, and synchronously effected consecutive exposures in each of the three batteries of cameras.

The intervals of exposures were recorded by the chronograph, and divided into thousandths of a second. These intervals could be varied at will from seventeen one-thousandth parts of a second to several seconds.

The task of making the original negatives was completed in 1885; the remaining years have been devoted to the preparation of the work for publication.

*KEY.*

| | *Rt.* | *Left.* |
|---|---|---|
| *Hind Feet* | ● | ○ |
| *Fore Feet* | ▲ | △ |
| *Line of ground* | ●○ | |

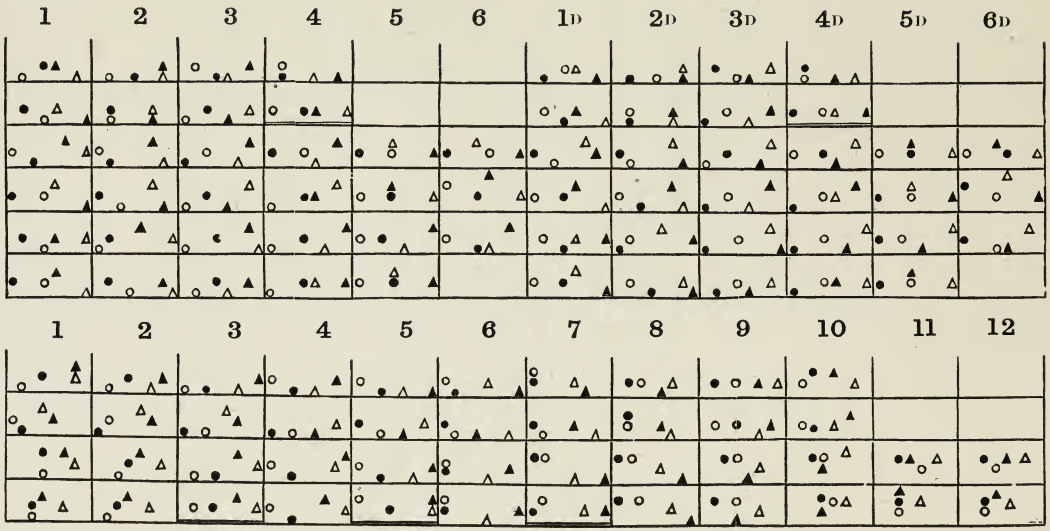
LATERAL elevation of some consecutive phases of action by representative horses.

Each line illustrates the successive fallings of the feet during a single stride.

After the last phase illustrated, the feet, during continuous motion, will revert practically to their position in the first phase.

The comparative distances of the feet from each other or from the ground are not drawn to scale; and, in any event, would be merely approximate for the succeeding stride.

| Action. | Length of Stride. ft. | in. |
|---|---|---|
| 1. Walking | 5 | 9 |
| 2. Trotting | 7 | 6 |
| 3. ,, | 17 | 6 |
| 4. ,, | 18 | 3 |
| 5. Ambling | 10 | 3 |
| 6. Racking | 12 | 6 |
| 7. Cantering | 10 | 3 |
| 8. Galloping | 11 | 9 |
| 9. ,, | 9 | 19 |
| 10. Galloping, a conjectural stride of 22 feet or more | | |




In the conjectural stride No. 10, phase 3 is very doubtful, phases 5 and 7 seem probable in a very long stride.

## DESCRIPTION OF THE PLATES.

The results of this investigation are

**Seven Hundred and Eighty-one Sheets of Illustrations,** containing more than 20,000 figures of men, women, and children, animals and birds, actively engaged in walking, galloping, flying, working, jumping, fighting, dancing, playing at base-ball, cricket, and other athletic games, or other actions incidental to every-day life, which illustrate motion or the play of muscles.

These sheets of illustrations are conventionally called "plates."

Each plate illustrates the successive phases of a single action, photographed with automatic electro-photographic apparatus at regulated and accurately recorded intervals of time, *consecutively* from one point of view; or, *consecutively* AND *synchronously* from *two*, or from *three* points of view.

**Each Plate is complete in itself without reference to any other Plate.**

When the complete series of twelve consecutive exposures, from each of the three points of view, are included in ONE Plate, the arrangement is usually thus:—

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Laterals. |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Rear Foreshortenings from points of view on the same vertical line, at an angle of 90° from the Laterals. |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Front Foreshortenings from points of view on the same horizontal plane, at suitable angles from the Laterals. |

The plates are not *photographs* in the common acceptation of the word, but are printed in PERMANENT INK, from gelatinised copper-plates, by the New York Photo-Gravure Company, on thick linen plate-paper.

The size of the paper is 45 × 60 centimetres—19 × 24 inches, and the printed surface varies from 15 × 45 to 20 × 30 centimetres—6 × 18 to 9 × 12 inches.

The number of figures on each plate varies from 12 to 36.

To publish so great a number of plates as one undivided work was considered unnecessary, for each subject tells its own story; and inexpedient, for it would defeat the object which the University had in view, and limit its acquisition to wealthy individuals, large Libraries, or Institutions where it would be beyond the reach of many who might desire to study it.

It has, therefore, been decided to issue a series of One Hundred Plates, which number, for the purposes of publication, will be considered as a "COPY" of the work. These one hundred plates will probably meet the requirements of the greater number of the subscribers.

In accordance with this view is issued the following

*PROSPECTUS*

# ANIMAL LOCOMOTION,

AN ELECTRO-PHOTOGRAPHIC INVESTIGATION OF CONSECUTIVE PHASES OF ANIMAL MOVEMENTS,

BY

EADWEARD MUYBRIDGE.

1872–1885.

PUBLISHED UNDER THE AUSPICES OF THE

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|---|---|---|
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| 2. | ,, pelvis cloth | 72 |
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| 4. | Women, draped | 60 |
| 5. | ,, transparent drapery and semi-nude | 63 |
| 6. | ,, nude | 180 |
| 7. | Children, draped | 1 |
| 8. | ,, nude | 15 |
| 9. | Movements of a man's hand | 5 |
| 10. | Abnormal movements, men and women, nude and semi-nude | 27 |
| 11. | Horses walking, trotting, galloping, jumping, &c. | 95 |
| 12. | Mules, oxen, dogs, cats, goats, and other domestic animals | 40 |
| 13. | Lions, elephants, buffaloes, camels, deer, and other wild animals | 57 |
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| | Total number of Plates | 781 |

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## VALEDICTORY.

This is not exactly the place nor the time for the Author to express his obligations and thanks to those gentlemen who have assisted him in his labours, but it affords a perhaps not inappropriate opportunity for him to pay a tribute of gratitude to his recently deceased friend M. Meissonier, without whose enthusiastic encouragement it is probable the present work would never have been undertaken.

In 1882 he invited his friends to attend an illustrated Lecture given in his studio by the Author, and then referring to a full knowledge of a subject being necessary for it to be truthfully or satisfactorily translated by the artist, declared how much his own impression of a horse's

motion had been changed after having carefully studied its consecutive phases. Attention need not be directed to the modifications in the expression of animal movements now progressing in the works of the Painter and the Sculptor.

The investigations of the Author are so well known, and so generally recognised as affording the only basis of truthful interpretation or accurate criticism of Animal Movement, that it is unnecessary to quote from the many elaborate reviews of "Animal Locomotion," which have been published in the American, English, French, and German Scientific, Artistic, and other Journals.

For the value of the present work to the general student of Nature and the lover of Art, no less than to the Artist and the Archæologist, the Physiologist and the Anatomist, it is with much pride and gratitude that he refers to the annexed list of some of his European subscribers.

E. M.

10 Henrietta Street,
Covent Garden,
London,
*August* 1891.

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PHYSICISTS, ETC.

Abney, Capt. W. de W.
Bellati
Blazerna, Pietro
Bramwell, Sir Fredk.
Bunsen, R.
Ditscheiner, L.
Glaisher, James
Hagenbach-Bischoff
Helmholtz, H. von
Huggins, Wm.
Julius, V. A.
Mach, E.
Matthiessen, L.
Moss, Rich. J.
Quincke, Georg
Righi, Augusto
Roiti, Antonio
Rousseau, E.
Soret, C.
Tissandier, Gaston
Thomson, Sir Wm.
Vogel, H. W.
Weber, H. F.

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Moltke, Field Marshal Count von
Portland, The Duke of
Wharncliffe, The Earl of
York, The Archbishop of